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3D X-FEM crack propagation under rolling contact fatigue

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ABSTRACT

To optimize the rail grinding strategy, the prediction of crack growth rates has a vital role.

Contact, with friction between the crack faces, notably occurs in rolling contact fatigue (RCF) problems. These time-dependent, multi-axial, non proportional loadings may lead to a crack initiation and propagation, and sometimes to the development of very complex 3D crack network.

Numerical simulations of frictional fatigue crack are efficiently performed using the eXtended Finite Element Method (X-FEM). A 3D two-scale frictional contact fatigue crack model developed within the X-FEM framework is presented in this article [1]. It allows the use of a refined discretization of the crack interface independent from the underlying finite element mesh and adapted to the frictional contact crack scale. The model is used here to analyze the crack propagation, rate and direction, under rolling contact fatigue. The wheel-rail contact loading is modeled as a traveling hertzian load. The stress intensity factors are computed at the crack tips during the wheel passage. Criteria for determining crack growth direction under multiaxial non proportional conditions and mixed mode Paris' law are used [2].

Actual residual stresses are accounted for in the simulation. They are determined thanks to a dedicated model used at SNCF in which the asymptotic mechanical state of the rail is computed when submitted to cyclic loads [3]. A non-uniform elastic-plastic stabilized state is calculated and introduced, by projection of the mechanical fields onto the finite element mesh, in the crack propagation simulation.

All this strategy has been implemented in CAST3M and is now used to model 3D frictional crack growth under RCF.

REFERENCES

[1] A. Gravouil, E.Pierres and M.-C.Baietto. Stabilized global-local X-FEM for 3D non-planar frictional crack using relevant meshes. *Int. J. of Num. Meth. in Eng.*, Vol. **88(13)**, 1449–1475,2011.

[2] M.-C. Dubourg and V. Lamacq.. A predictive rolling contact fatigue crack growth model: Onset of branching, direction, and growth - Role of dry and lubricated conditions on crack patterns. *Jnl. of. Tribology*, Vol. **124**, 680–688, 2002.

[3] M.L. Nguyen-Tajan and C. Funfschilling. A numerical modeling strategy for the rolling contact fatigue analysis of rails, . *WCRR 2011*.